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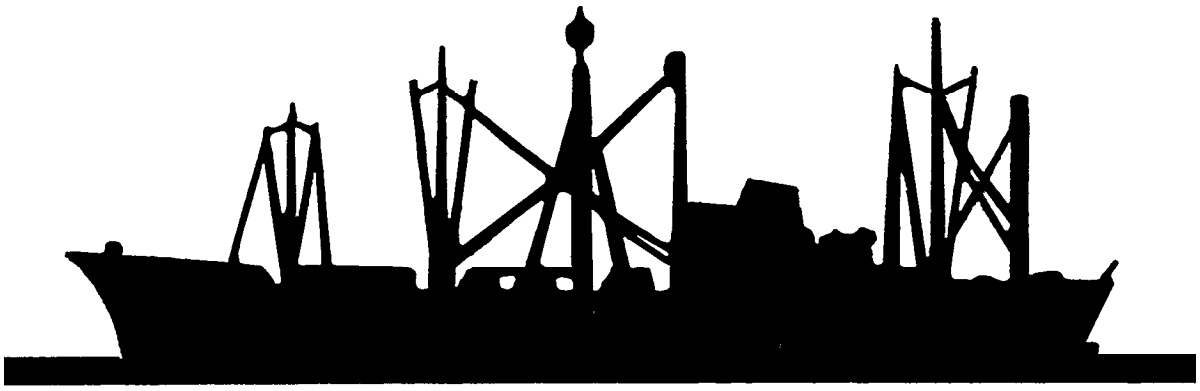

INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

IREAPS

A CASE STUDY USING MODELS IN THE SHIPBUILDING INDUSTRY

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ABSTRACT

Engineering models can be a better way to accomplish project objectives and open new doors for improvements in operational and management techniques. Thinking must be changed from studying and designing on paper to designing on a model. Initial modeling efforts may be difficult but some of the problems can be reduced by the lessons learned. When an appreciation of the value of models and the ease by which they can be constructed is gained, the model will become part of the standard design procedure. The benefits are great.

I. INTRODUCTION

We want to thank the organizers of this Conference for including a paper on engineering models. My recent experiences lead me to believe that the shipbuilding industry is on the threshold of developing new systems to aid design. Some of these new systems include models;

Most of the A/E firms in the United States currently use models. Some of the major A/E firms in the United States are making use of engineering model/computer systems and have been for many years. The shipbuilding industry, including, the. Navy, the naval architects, and the shipbuilders, can learn from things already happening. Some are, for instance, a report from Odense Shipyard states, "The Odense Shipyard has developed perhaps the most unique integrated piping design/engineering systems, in that the computer-aided system is based on the use of:' scale models."

When asked if we would present a paper at this Conference, we gave considerable thought to the commercial aspect of our message. Let me say now - yes, we will sound like we are selling the model concept - and maybe we are. But today, with the emphasis on labor cost and safety, and other problems related to improving design and productivity can you afford to overlook any tool that improves performance?

II. BACKGROUND

A. HISTORY

Engineering models have been around for about 30 years. The original models were built from wood, plastic, and metal and were crude and inaccurate by today's standards. These models were built from finished and checked drawings. It was not until the late 50's that models started to gain acceptance as a piping design tool. This was primarily due to the fact that the model was taken out of the model shop and placed on the design floor. Other contributing factors were the increased availability and range of mass produced model parts, the simplicity and accuracy with which models could be built, and the demand by users.

B. WHAT ARE ENGINEERING MODELS

Engineering models have been referred to as 3D drawings and scale reproductions. However, today the engineering model is being referred to almost universally, as a communication and design tool.

C. WHY USE MODELS

Engineering models are bridging the gap between design, construction, and the client. Engineering models can be a better way to do things and can accomplish design, construction and plant operations objectives more effectively. Let's look at three areas where models can play a key role.

1. Design

Today, designing is more involved and complicated. Detailed engineering drawings are only fully comprehended by a trained few. And when these engineering drawings number in the hundreds and thousands, it is only the trained few that can visualize all of the details and arrive at a clear picture of the whole project. Design quality and performance are vastly improved when using a model because designers and engineers can more quickly see alternatives.

a. Confidence

Conflict free

Costly interferences are eliminated. You have a conflict free design.

- Quality

Models improve the quality of design. Mistakes are made on the model and not during construction.

You will have confidence in your design. You know you will end up with better arrangement of equipment and piping systems and know that the plant can be built.

b. Contribution

- Visibility

Look at it this way, all disciplines are shown on a single drawing - the model. The draftsperson and designer can contribute more to the total project in a shorter period of time. A model gives better visibility of the project. You can see things on the model that you cannot see on paper.

- Accelerates schedules

Models will help to speed up design. No changes upon changes. The designers see the total picture. Coordinating time is reduced throughout the project. Decisions are made faster.

Normally a designer should wear 3 hats.

First he must design the plant. Then he must put on his constructor's hat and evaluate the design in terms of construction. Then he must place himself-in the position of the operator and determine if the plant can be operated and maintained. The designer can do all of these things better and make a greater contribution when using a model.

C. Communication

- Management Aid

Management is able to obtain maximum use of all their people's talent and experience. The model helps to

plan, schedule, and re-assign work priorities.

- Involvement

Managers become more involved because they can see progress and problems and can make decisions faster.

- Review

How do you conduct a design review without a model?

- Status

The model clearly shows holdups. No surprises - you can see what is happening. What better way as a manager or project engineer can you review progress?

There must be communication to convert the ideas to design. With a model you have improved this process. You have a tool that provides a common ground for communicating.

2. Construction

The greatest cost saving attributed to a model is from its uses as a construction aid. A model allows all crafts and subcontractors to see the overall scope of the project and minimize the interpretation of the construction drawings.

Planning/Scheduling

Construction schedules are prepared more quickly and more reliably from using a model. Rescheduling is accomplished more effectively.

Construction management

A model helps to understand your plant better. You can prepare better specs for procurement. Subcontractors can see each others requirements and can interface better.

Input to design

The construction superintendent can make input to design early in the design phase, rather than during construction.

Erection sequence

Models aid in effectively locating construction equipment. At the construction site a model is worth a pile of drawings. With today's complex processes, no single person can visualize a complete plant. A model lets every body see the same thing.

3. Plant Operations

With emphasis on safety and labor costs, the model provides an extra payoff when it is used to aid the planning and operation of the plant.

Operator training

Operation training manuals can be prepared while the plant is being constructed. Personnel can be oriented to a new plant and equipment long before it is placed in operation.

Safety studies

Safety studies can be conducted and necessary precautions identified and procedures prepared.

Maintenance studies

Future maintenance studies can be conducted and maintenance procedures prepared. Maintenance is more easily understood.

The model can be used to plan start up sequences. After that the client can use the model for all future planning and studying of changes and continuous operator training.

III. MODELS AS RELATED TO SHIPBUILDING

The complex, curved structure of the hull of a ship presents a major problem to the designer and the builder. Visualizing a three dimensional design within a non-rectangular space is not an easily developed skill. When the space is then filled with machinery and equipment connected by miles of piping, tubing, ducting and electrical cables, the problems are compounded. This is then further complicated by specialisits within their own fields working separately on parts *of* the design. Coordination of these efforts is a major problem.

In order to coordinate the efforts of the designers and prevent interferences from occurring in ship, engineering drawings, composite drawings have been traditionally used. These drawings show all of the piping, duct work, cable ways, etc. in an area on one drawing. As can be imagined, the composites become very complex and difficult to read. Errors can readily creep in. Further, it is a demanding but essential task to keep the composite drawings current as the job progresses.

Models have been used in past ship design efforts by various shipyards and design agents and are being seriously considered as a regular design tool. In addition to the tangible benefits of improved design, lower construction costs, and as an operator training aid, ship engineering models have various intangible benefits.

Some of the intangible benefits are like an insurance policy -- the value is evident at a later time. We do know that models offer a better design approach than drawings. The best design can be produced in the shortest possible time. Models allow the better use of the

available people. Most of the experienced people are in a position where they have little time to review drawings. If something is wrong and a model is being used, the problem will be found while there is still time to do something about it and before costly construction changes are involved. But, perhaps the greatest benefit of a model is its use as a communication tool.

IV. CASE HISTORY

Sun Ship like probably all shipyards has used modeling for various aspects of ship design and construction for many years. These models included hull form, structure, piping and machinery. While some models such as for anchor handling have been used for almost every design, models of the machinery spaces have been used only sporadically. Recently Sun Ship did use models to aid in the design of the machinery spaces and pump room of a specific project, the Medium Class Hopper Dredge currently under construction for the Corps of Engineers.

While there may be a tendency to equate a dredge with a barge, the MCHD is not simple. It is in fact a very complex ship -- in structure, machinery and piping. The basic layout is a more or less conventional machinery space aft and a large, complex pump room forward connected by highly congested accesses through the hopper space void ares.

Sun Ship contracted with USA Models to build models of the Pump Room, Engine Room and a section of the Hopper Area. These models were not included in the initial planning for the project, but were added as the need for them was recognized. The first section to be modeled

was the hopper area. This was triggered when a change order required the installation of additional piping through already congested hopper voids. It was also recognized that bringing this piping into the engine room and pump room might involve problems and that therefore an examination of the bulkhead penetrations might be valuable. The modeling effort rather rapidly expanded to include the complete pump room and engine room as well.

The design effort for the MCHD was performed by a design agent, J. J. McMullen Associates and was done at their New York and Newport News offices. The models however, were built at Sun Ship and at the USA Models plant in Pennsylvania. As a result, the models were not physically available to the JJMA designers on a day to day basis as the design effort progressed. The models therefore served more as a check on the design rather than a designing tool. There were however numerous occasions when valuable design input was obtained from the models.

> The prime purpose in building the models was to reduce the engineering problems which would be encountered during construction of the ship. This of course is expected to decrease the rework and delays which might otherwise be encountered. Productivity improvements are expected and are being achieved from both the lower level of unplanned work and the better schedule adherence than would otherwise have been encountered.

The model technicians reported a total of 412 problems in the construction of the three models. The reported problems were fed back to the design

agent as they were encountered. Of the total, 33 problems were reviewed by J. J. McMullen Associates and evaluated as not requiring any change to the drawings.

A total of 379 problems reported by the model technicians resulted in one or more changes to a drawing.

The types of problems uncovered included:

- Structural design errors
- Foundation problems
- Interferences
- Pipe detailing errors including
  - Incorrect dimensions
  - Flange orientation and attachment problems
- Material list errors
- Holes list errors

While none of the problems were momentous, if they were allowed to reach the construction stage without correction, the total impact would have been appreciable. Consider for example, the relatively simple problem of failing to leave a loose flange on a length of pipe which has to run through a hole in a structural member. How many manhours does it take to correct the problem when the prefabricated pipe can't be installed at the job? Would 2 men for 1 day or 16 manhours be reasonable? At that rate, the flange error could cost $300-400 in labor alone. The flange error will also have a schedule impact. The work on that part

of the job at least will be a day late. If that can't be made up or absorbed by a buffer, the-delivery could conceivably be delayed by a day or even more. The actual cost of the flange error, like the proverbial horseshoe nail, could be great. When multiplied for a series of small errors, the total cost could grow geometrically.

Due to the usual limited available resources and the size of the task, a detailed cost benefit analysis for modeling of the MCHD was not attempted.

V. LESSONS LEARNED

Modeling can make a significant contribution to the shipbuilding industry -- and can make that contribution today. There is no need to wait for future developments. It is possible to gain greater benefits from modeling than were achieved in the MCHD project. Some of the actions needed to obtain the greater benefits possible from modeling are:

A. Include modeling in the initial plants and schedules. Model building takes time. To obtain the full value from a model, the building of the model has to be planned and scheduled as part of the overall project schedule.

B. Design with the model. The model and the model technicians can be a great assist to the designers. The design effort will go faster and with fewer errors.

C. Introduce model building to the organization with care. The modeling function can be perceived as a job threat to the designers. For

maximum benefit however, the designers have to use the model and work with the model builders as a team.

D. Locate the model technicians physically with the designers. Physical separations undermine the effort to have the designers and model builders work as a coordinated team.

E. Designate a coordinator -- with some clout. Someone has to keep the information flowing both ways and to smooth out any problems between the designers and the model builders as soon as they develop.

F. Establish and publish procedures for the model technicians and designers to follow. Confusion as to what they can expect from each other can cause a rapid breakdown of any cooperative spirit.

G. Set specifications for the model and the model technicians. This includes the areas to be modeled, the scale and color schemes. Set tolerances for the model. Model makers can work to tolerances far closer than those to which ships are built. Working to this degree of accuracy is wasted effort from a shipyard's point of view.

H. Prepare a schedule and establish a budget for the model and then require the model builders to adhere to them. Model building is much like any construction project. If you do not exercise control, the costs will grow and the schedule will slip.

I. Don't start acomplex design project without a model!

VI. THE FUTURE

During this symposium, we have heard many exciting papers on the use of computers to improve productivity in shipbuilding. Unfortunately, many of the benefits of the application of computers to ship design still lie ahead of us and some significant problems remain.

Modeling, while perhaps more prosaic than computer applications, is a design tool available to the shipbuilding industry today.

A skilled model builder is actually a designer working with plastic and solvent instead of paper and pencil. Some of the advantages of the three dimensional model over the two dimensional drawing have been covered today. There are some disadvantages as well.

Models take up space and are not portable. Some of the other concerns might be that changes to the model may be more difficult to make than to a drawing. Furthermore, even when modeling, working drawings or sketches are required for shop use. Transferring the design from a model to a drawing can result in errors and mistakes.

An ideal system for engineering design would incorporate the presentation advantages of the three dimensional model, the ease of change of the pencil and eraser and the automatic preparation of drawings of computer assisted drafting. The computer holds forth the promise of evolving into such an ideal design system, but it is not there yet. Shipboard machinery spaces are still too complex. However, a combination of models and computers can be used today and can achieve an approximation of the ideal system.

Physical models have proven to be excellent inputting devices for computers. With the data from the model, the computer can perform the necessary calculations and prepare the paper output. In this sense, computers and models are not really competitive techniques but are actually complementary. The synergism of using a combination of the two techniques together can achieve a level of effectiveness greater than the simple sum of either technique alone.

Some day, we would expect computers to supplant model building. At that time, the model builder and the designer/draftsman will probably have merged into a single profession.-- the computer based designer -- a designer who works with complex, 3 dimensional designs without ever touching plastic or solvent, paper or pencil.

John belongs to the American Engineering Model Society, a professional society composed of model technicians and management people. The primary aim of the society is to promote and improve the modeling techniques and contribute to quality design and productivity. In 12 years of holding formal seminars and presenting technical papers, only one paper has been presented having to do with shipbuilding. That paper was by Vickers Ltd. in 1972. To our knowledge only one book was published and that was by the Maritime Administration in cooperation with Todd Shipyards, published in 1974. It is one of the finest books available on models.

Planning and imagination must be applied constantly to improve productivity, keep costs down, and create producible designs. In the power and industrial plant design and construction industry, models are the heart of a vital process and are helping to create quality designs and aid in construction.

We believe that the Shipbuilding industry is on the verge of a rapid expansion in the use of engineering models.

Thank you.

POST SCRIPT

A film is available through the AEMS. It is about Stone & Webster's engineering model program.

Also a variety of literature is-made-available through the courtesy of the American Engineering Model Society and Engineering Model Associates.

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